LEVINSON

Design of a steel grand-stand

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DESIGN OF A STEEL GRAND-STAND

BY

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This is to certify that the thesis of LAZARUS LEVINSON entitled Design of a Steel Grand-Stand is approved by me as meeting this part of the requirements for the degree of Bachelor of Science in Civil Engineering.

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DESIGN OF A STEEL GRAND-STAND.

INTRODUCTION.

The object of this thesis is to design a steel grand-stand for the east side of the gridiron on Illinois Field. Since the track is to encircle the gridiron, the writer thinks that the stand should be somewhat longer than the length of the gridiron, or about 350 feet.

Within recent years, steel grand-stands have been replacing wooden structures, due to: (1) the great advance in the price of lumber; (2) greater safety from fire and weather; and (3) the fact that capital is being interested, and there is a demand for increased seating capacity. The first stand of of any importance was built in 1890, at Monmouth, New Jersey. It is 700 feet long, 210 feet wide, and has a seating capacity of 10,000 people. The stand has a cantilever roof, which projects 75 feet to the front and 25 feet to the rear. The grand-stand erected at Yonkers, New York, for the Empire City Trotting Club is also of the cantilever type of roof construction, extending 25.5 feet in the front and 15.5 feet in the rear. Until a few years ago, the largest and most expensive grand-stand was located at Belmont Park, on Long Island. It is 50 feet high, 650 feet long, 116 feet wide, and has a seating capacity of 11,000. The cost of the stand was $450,000. Within the last five years, owing to a greater interest in ball games in the larger cities of the country, baseball magnates have built steel grand-stands of large proportions. The one

built on the Pittsburg grounds and opened in the summer of 1909 is the largest of its kind. The grand-stand which is now under construction on the Chicago "White Sox " grounds will when completed rival the Pittsburg stand.

DESIGN.

The grand-stand designed by the writer is 350 feet long, 65 feet wide, and 53.3 feet high, and has a seating capacity of 6000 people. The roof is of the cantilever type, projecting 26 feet in the front and 7 feet in the rear. The front columns were placed 50 feet apart, and the rear ones 16 feet 8 inches. The roof-trusses were placed 16 feet 8 inches apart, and rest upon the rear columns and the intermediate trusses, which were designed to span the distance between the front columns.

The stresses were all obtained by graphic methods. The stress diagram, together with the table of stresses, are shown in PLATE I.

An end view, showing the truss, the seats, the footings, the columns, the bracing, and general details, is shown in PLATE II.

The roof-trusses (see Plate III) were designed for dead load, minimum or maximum snow, and wind load. The dead load consists of the weight of the gravel, roof covering, sheathing, rafters, purlins, and trusses; and was taken as 20 pounds per square foot of horizontal projection. The minimum and maximum snow loads were taken as 10 and 20 pounds per square foot of horizontal projection, respectively. The wind load was based

on Duchemin's formula for a wind load of 30 pounds per square foot of vertical projection, which gives 20 pounds per square foot normal to the surface. The roof has a pitch of 1:6. The maximum stress for the design for each roof-truss member (see Plate III) was obtained by combining the dead load, the minimum snow load, and the wind load, or by combining the dead and maximum snow loads.

In determining the wind stresses in the roof-truss, the rear column was considered as fixed by its connection to the seat-truss and by the knee-brace. Consequently there is no bending moment in the front column. All the horizontal wind was considered as taken up by the front support, thereby necessitating a very heavy footing, or anchorage. The columns are composed of a box-section, made up of two channels, laced back to back. The main columns are continuous to the lower chord of the roof-truss, as it was not considered economical to extend them to the top chords. The channel columns were compared with Z-bar and angle columns, and were found to be more economical. All columns (see Plate II) were designed for direct stresses.

In designing the footings (see Plate II) the bearing power of the soil was taken at two tons per square foot.

The seat-beams (see Plate II) were designed for a combination of dead load, live load, and wind load. The dead load consists of slag concrete, the weight of which was taken at 110 pounds per cubic foot, angles, plates, and lumber; and was taken as 53.3 pounds per square foot of horizontal projection.

In computing the load due to the people in the stands, the writer considered both the people standing on their seats and others standing or walking in the space between the seats. This load was taken at 75 pounds per square foot of horizontal projection, making in all 123.3 pounds per square foot of horizontal projection. This was made on the assumption that the average person weighs 150 pounds. The wind acting from the left was taken at 20 pounds per square foot of vertical projection.

Plate IV shows the general plans and elevations of the grand-stands, together with the general dimensions.

Ketchum's General Specifications for Steel Frame Mill Buildings were used in the design. The following allowable unit stresses were used:

Tension = 16,000 pounds per square inch.

Compression = $16,000 - 70 \frac{l}{r}$, where l = length of member in inches, and r = least radius of gyration. The maximum value of $\frac{l}{r}$ used was 125.

In designing the riveted connections, 11,000 pounds per square inch was the allowable shearing stress, and 22,000 pounds per square inch for the allowable bearing stress.

The smallest angle used was 2"x 2"x 1/4".

ESTIMATE OF COST.

The cost of the grand-stand is as follows:

645,350 pounds of steel @ 3 $\frac{1}{2}$ ¢	$22577.25
22,760 square feet of corrugated steel @ 3 $\frac{1}{2}$ ¢	796.60
980 feet of 1" gas pipe @ 9¢	88.20
180 feet of 1 1/2" gas pipe @ 12 ¢	21.60
55,000 board feet of lumber @ $28 per M.	1540.00
412.5 cubic yards of concrete @ $7	2887.50
28,875 square feet of gravel roofing @ 5¢	1443.75
TOTAL ESTIMATED COST	$29354.90

PLATE I

STRESS SHEET
GRAND STAND

PLATE II

DETAILS

GRAND STAND

PLATE III.

DETAILS
OF
ROOF-TRUSS
For
GRAND STAND
Thesis Work
By
L. Levinson
University of Illinois
1910

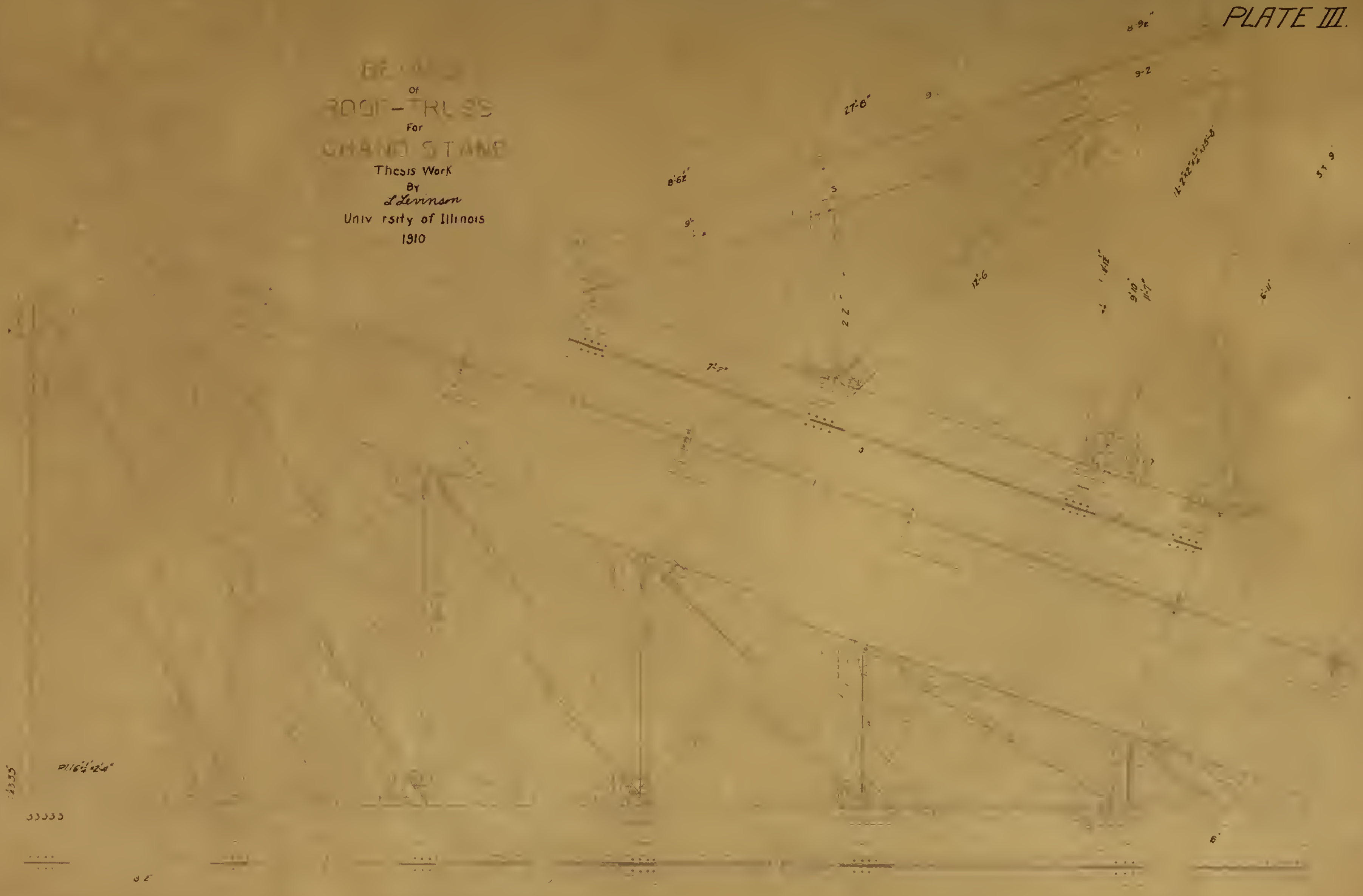

PLATE IV.

GENERAL
PLAN AND ELEVATION

GRAND STAND

[illegible] Illinois